Biofuels: An Important Part of a Low-Carb Diet

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The Union of Concerned Scientists is a science-based organization in DC, Berkeley, CA, and Cambridge, MA, involved in energy and environmental issues. By "low-carb diet" in my title, I mean reducing the carbon intensity of the fuels that we use to address climate change.

Future energy solutions will have to address three main challenges:

- strategic, *e.g.* increasing energy security,
- economic, *i.e.* they will have to be economically feasible and sustainable and promote economic development, and
- be environmentally sound, *i.e.* reducing all forms of energy-related pollution.

I will concentrate on the last, mainly in terms of global-warming pollution.

Transportation and Climate Change

Climate change and global warming are much in the news. The United States is the largest global-warming polluter. Figure 1 shows the carbon emissions due to fossil-fuel combustion for 2003; transportation accounts for about a third, counting only what comes out of the tailpipe. If upstream emissions are included—production of fuel, *etc.*—it's about 40% of the US global warming pollution. Cars and trucks in the United States, including the upstream emissions, account for about 25% of the total global warming pollution, approximately the same as the entire economies of all other countries combined, except China and Russia.

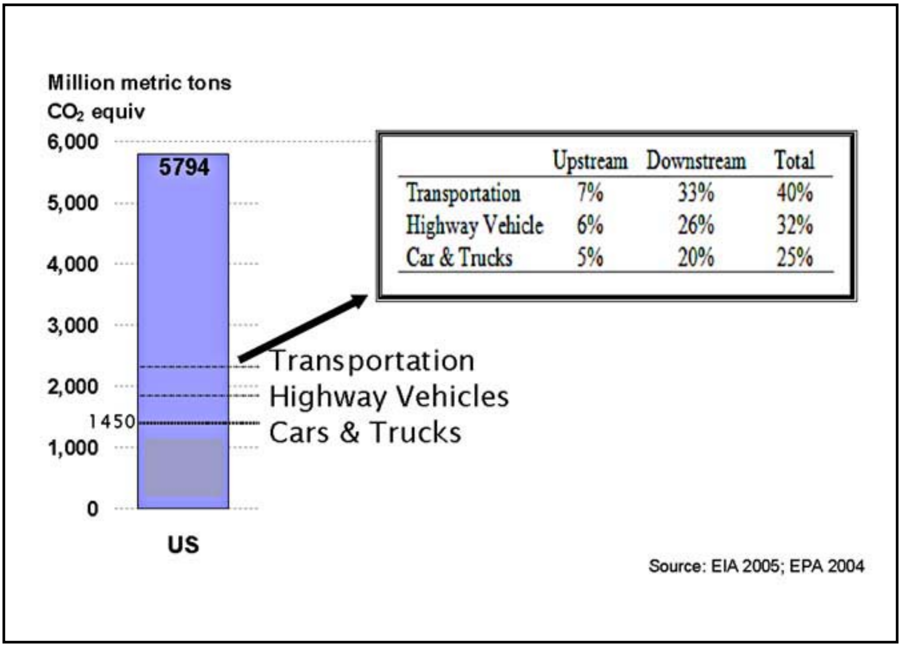

Figure 1. Global-warming pollution from the United States, 2003.

Consumption of petroleum in the United States is expected to increase by about 30% by 2030 and the import gap is growing because domestic production is staying constant (Fig. 2). So, people are looking for opportunities for petroleum replacement, such as extraction of tar sands from Alberta, gasification of coal, and biofuels. More use of electricity for transportation is likely, and possibly, eventually, hydrogen for fuel cells. In examining replacement choices, we need to look at the entire life cycles, including upstream emissions involved in feedstock production.

Life-Cycle Considerations

Figure 3 shows various fuels relative to gasoline in terms of lifecycle global-warming pollution. Broad ranges are shown because aspects of the calculations are uncertain. There is much we need to understand before making choices for the long term. The values for coal liquification ("coal-to-liquid," CTL) do not include sequestration of carbon; if carbon dioxide is sequestered, then the global-warming pollution will be similar to that for gasoline. Currently there is debate in Congress regarding CTL vs. biofuels relative to the Renewable Fuel Standard. Senators from coal states are pushing to include CTL in the discussion. And in his 2007 state-of-the-union speech, President Bush said that he wants to increase the use of renewable and alternative fuels up to 35 billion gallons by 2017. The term "alternative" includes CTL. Therefore, as we move down this road to

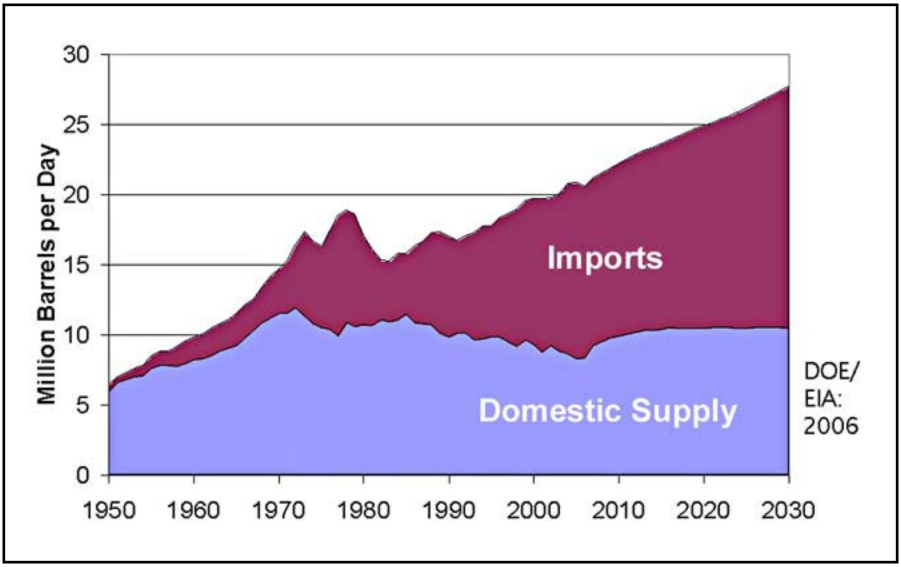

Figure 2. US sources of petroleum

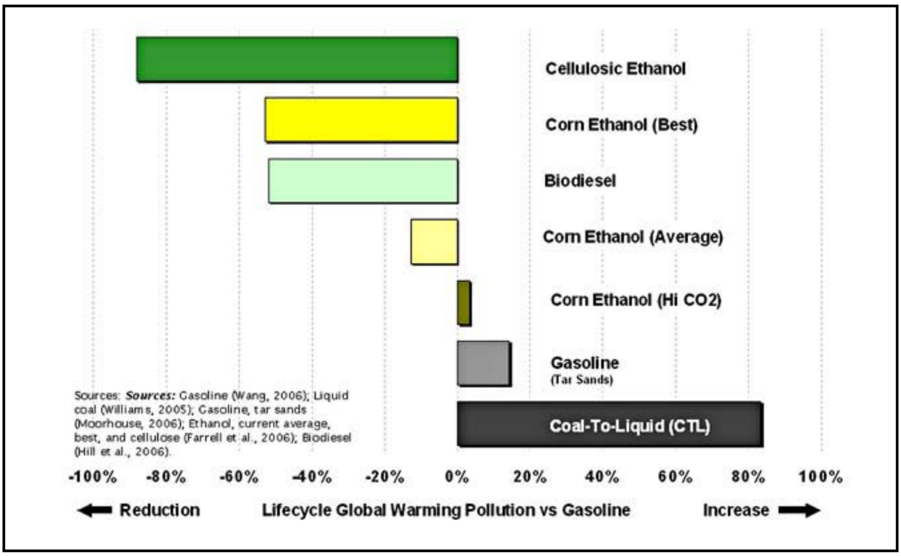

Figure 3. Global warming pollution: renewable and alternative fuels relative to gasoline.

renewable and alternative fuels, we need to evaluate each in terms of the full life cycle, including global-warming impact, because the solutions to our energy needs must meet all three of the highlighted criteria.

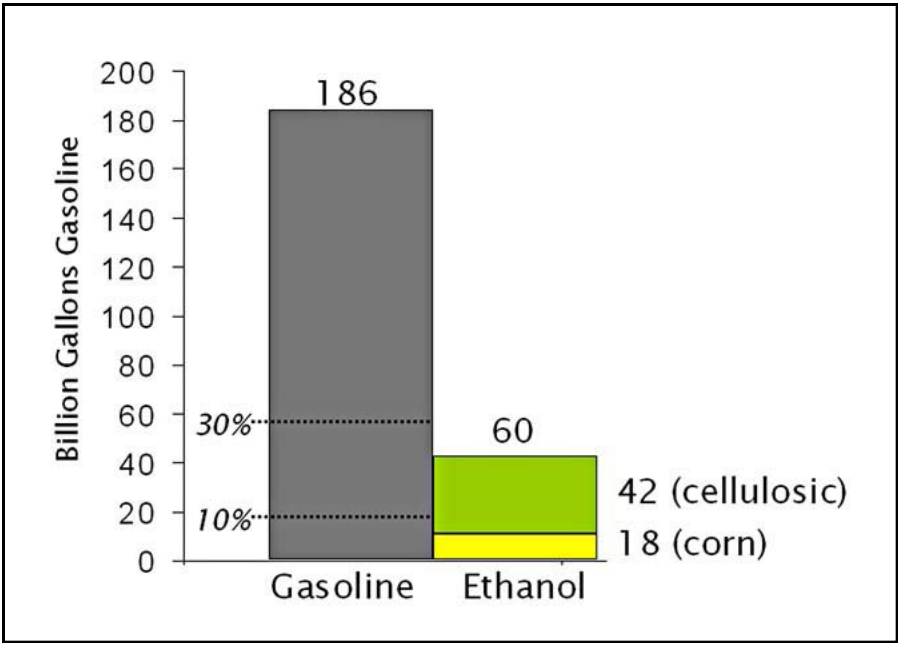

Figure 4. Ethanol production by 2030?

Biofuel Limitations

The amount of petroleum that we can displace with ethanol is limited, as it is for diesel and biodiesel. Right now, the United States is producing about 5 billion gallons of ethanol and consuming about 136 billion gallons of gasoline per year. If we max out ethanol production from corn today, it accounts for about 15% of total crop production. So, complete replacement of gasoline with starch ethanol is not doable. The same is true for biodiesel; all the fats and oils in the United States would displace only about 10% of the diesel usage. Consequently, there is increasing interest in nonfood—non-corn, non-soy—biofuels, including cellulosic ethanol.

Most estimates indicate a maximum production of 15–18 billion gallons of ethanol from corn starch with 42 billion gallons from cellulosic sources by 2030 (Fig. 4). At 60 billion gallons/year, the United Stated would still be shy of 30% of its projected petroleum needs. Clearly, renewable fuels are not a silver bullet and we have to address our transportation needs comprehensively, including miles per gallon and vehicle miles traveled per year. Figure 5 provides a scenario analysis for business as usual and possible contributions from the three legs of the transportation stool by 2030. If there is a 4%/year mpg improvement, taking into account vehicle-stock turnover, it will provide 35% of the reduction. A reduction of 0.5%/year in vehicle miles traveled amounts to a 6% reduction, and starch and cellulosic ethanol combined may contribute 12%.

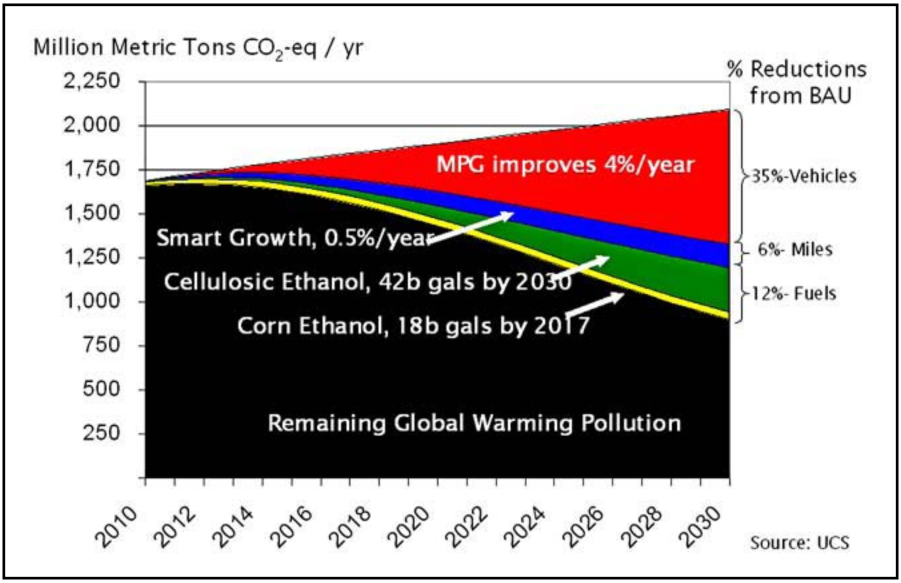

Figure 5. Potential reductions in global-warming pollution (US cars and trucks).

Policy Issues

Congress is considering policy to mandate improvements in corporate average fuel economy (CAFE) standards. California has some bills on the table to provide "febates," *i.e.* incentives to purchase fuel-efficient vehicles. Also, California is leading the way in minimizing greenhouse-gas emissions from vehicles, and twelve other states are following suit. From a policy standpoint influencing miles traveled is mostly a local issue, achievable mainly by encouraging mass transit. Tax credits have done much to build the ethanol and biodiesiel industries.

The renewable fuel standard, enacted in the 2005 Energy Policy Act, is now somewhat obsolete because it has been overshot by the growth in the renewable fuels industry. California announced in January 2007 that, by 2010, it would set carbon-intensity standards for all of the transportation fuels used in that state. With respect to R&D funding and grants and loan guarantees for deployment of new technologies, in 2007 the DOE announced $385 million for six cellulosic plants in various parts of the United States as the vanguard for cellulosic ethanol development.

Low-carbon-fuel policies need to focus on minimizing greenhouse-gas emissions, because renewable fuels are not necessarily beneficial for the environment. Such policies will drive the transition towards new and value-added markets. They will provide safeguards against higher carbon alternatives like CTL, and promote diversity of feedstocks and address some of the feedstock-limitation issues. They will minimize other unintended consequences of large-scale production of renewable fuels—*e.g.* by encouraging perennial biomass-crop production—and increase the market size for renewable fuels, which will support the domestic economy and spur global competition.

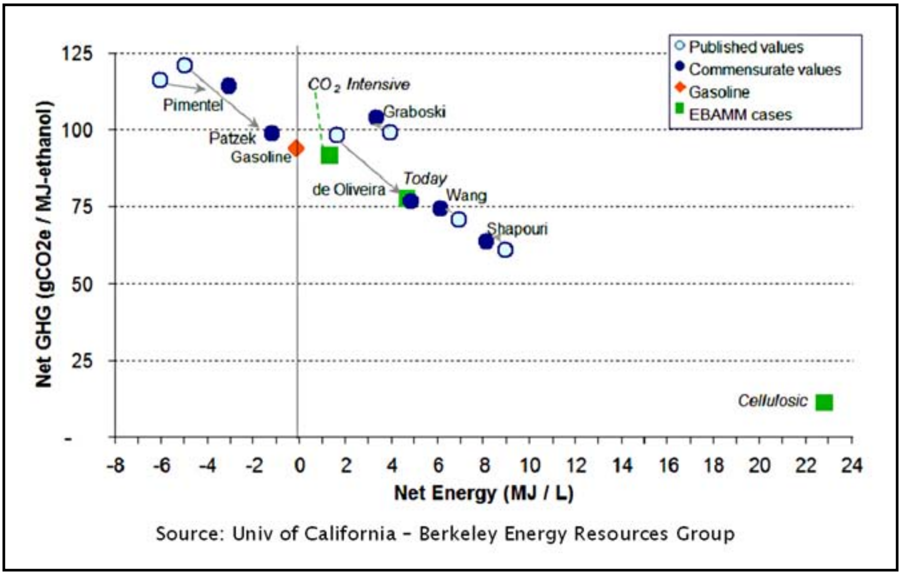

Figure 6. Disagreement on how to count "carbs."

Life-cycle analyses over the past 10 years have revealed much uncertainty in the data. In 2006, research at UC Berkeley examined six "well to wheel" life-cycle analyses for corn-starch ethanol and revealed contrasting numbers (Figure 6). On the X-axis is the energy loss or gain per unit volume and on the Y-axis is global-warming pollution as grams of CO_2 per unit of energy. Numbers determined by Pimentel and Patzek were on the negative side whereas more recent studies were more positive, but varied widely.

Energy-policy-related decisions are being made based on greenhouse-gas-emission reduction; having sound data is fundamentally important. In May 2007, the EPA announced the launching of a cost-benefit life-cycle analysis of biofuels for the upper Midwest. The best data available relate to the ethanol-production plants. Upstream from that, the numbers are less certain. Corn is being grown in various locations under a range of conditions and farm-management practices. A system is needed whereby these variables are accounted for.

The second bar in Fig. 7 denotes ethanol produced from corn starch at a plant that burns coal; there is no CO_2 advantage over burning gasoline. The third bar represents the current industry average—wet-mill and dry-mill plants using various sources of energy. The fourth bar represents plants now being installed, mostly dry-mill facilities powered by natural gas with a ~30% reduction compared to gasoline. The energy and emissions profiles are improved if the distillers grains are not dried (Fig. 7, fifth bar); some companies gain this advantage by placing feedlots next to the ethanol plant. With biomass used to power the boilers, the savings may be in excess of 50%.

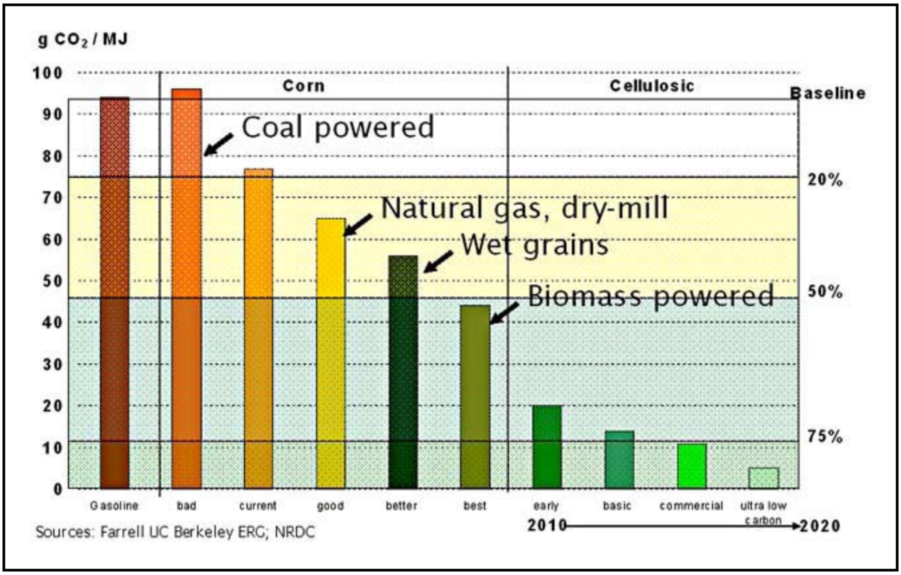

Figure 7. Global-warming impacts of ethanol produced under various conditions.

The reductions vs. the baseline projected for cellulosic ethanol (Fig. 7) are those being considered in Congress with reference to the renewable fuel standard (RFS). In the Bingaman bill, to be "renewable," the requirement is for 20% below the emissions baseline. The Bingaman bill ramps up from the current RFS, which caps out around 15 billion gallons per year (Fig. 8) from conventional biofuels (from corn starch), and then advanced biofuels (from biomass) make up the difference from ~2016. It is projected to rise to 36 billion gallons by 2022 with 21 billion from what's classified as advanced biofuels.

National low-carbon-fuel standard bills (from Boxer and Obama-Harkin) are under consideration, fashioned after the California bills. They have two phases for advanced biofuels (Fig. 9). Phase II represents 50% to 75% reduction and phase III is greater than 75% reduction vs. baseline. Therefore, over time, they are ramped up to obtain greater reductions in greenhouse-gas emissions. The line represents the low-carbon fuel standard, considering the total amount of transport fuels used, with an average for greenhouse gas emissions through 2010; the requirements are for a 5% reduction by 2015 and a 10% reduction by 2020. Similarly, the California fuel standard is for a 10% reduction by 2020. This is an aggressive production goal in view of the data presented in Fig. 4.

These bills take into account all forms of energy, not just biofuels. If plug-in hybrid vehicles become available soon, electricity will probably start to play in the mix for lower-carbon transport fuels within 5–10 years. This will complicate the situation in view of the fact that fuel standards today are implemented at the blender level. When a consumer plugs in a vehicle, where is the point of regulation? Despite this complication, this needs to be part of the mix for low-carbon transport energies.

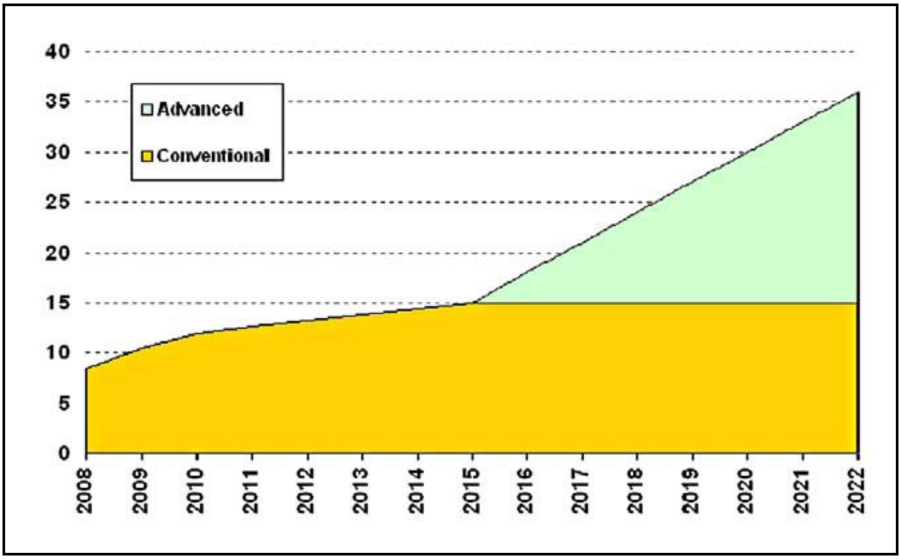

Figure 8. National renewable fuel standard (billions of gallons).

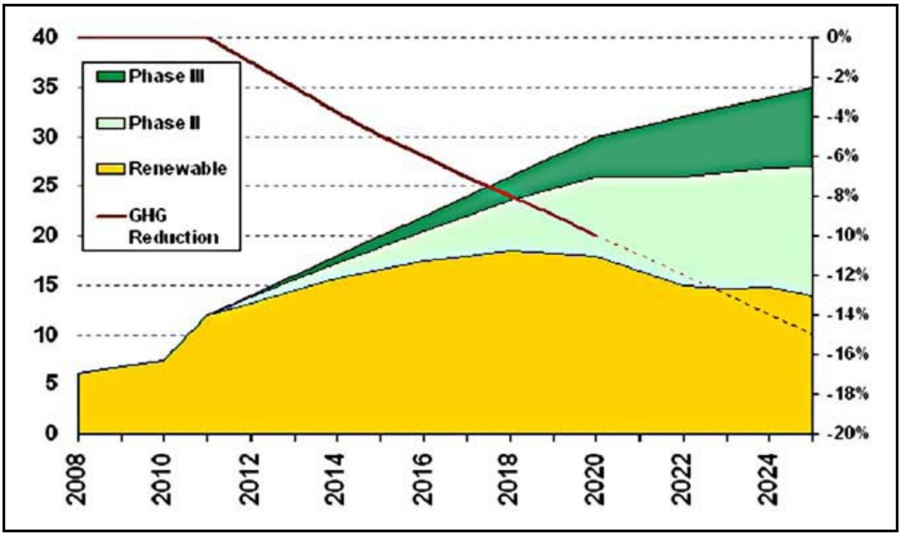

Figure 9. National low-carbon standard bills (billions of gallons).

In Summary

I've discussed minimizing the global-warming impact of the fuels that we use, their carbon intensity. As I demonstrated, we need to combine expansion of biofuel consumption with improvements in fuel economy and conservation and smart growth to reduce our demand for petroleum. Also, we need to make sure that expansion of biofuel consumption has no adverse effects on public health. We must not backslide on air-quality gains achieved in recent years, and we must promote ecologically sound bio-energy systems. Bio-energy developments will expand economic opportunity, hopefully not just for the ADMs and the Cargills, but for everyone along the supply chain who participates, including farmers in South Dakota as well as in India and Guatemala.

As a senior engineer in the Clean Vehicles Program of the Union of Concerned Scientists (UCS), **STEVEN BANTZ** analyzes and assesses transportation issues with a focus on biomass-based fuels and energy. He advocates for sustainable production and use of bioenergy in conjunction with aggressive increases in energy efficiency, reduced demand through conservation, and reforms in transportation and land-use policies (smart growth) to achieve timely reductions in greenhouse-gas emissions and dependence on fossil fuels.

Before joining UCS in August 2006, Mr. Bantz worked as a process control engineer for eighteen years with DuPont, and later Koch Industries, serving in various roles in operations support, R&D, project development in plant startups in Singapore, Brazil, China, Mexico, and the United States

He holds a bachelor's degrees in electrical engineering from the University of Illinois and in engineering and physics from Illinois College, and is finishing a master's degree in integrated science and technology at James Madison University. For his thesis, Bantz has developed a system-dynamics model to help understand the impacts of limited feedstock availability on the rapid expansion of the biodiesel industry.